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SELECTIVE CONTROL IN QUELEA POPULATIONS IN EASTERN AFRICA

MICHAEL M. JAEGER
Denver Wildlife Research Center, USDA/APHIS, Lakewood, Colorado 80225-0266 USA

Abstract. I describe the management of populations of the red-billed quelea (*Quelea quelea*) in eastern Africa for the purpose of protecting ripening cereals. The management strategy is to remove selectively only those quelea aggregations likely to come in contact with concentrations of vulnerable cereal. The opportunities for selective targeting vary among populations. Two models are presented here describing different quelea populations. The first is a general model to illustrate the relationship between migration, nesting, and damage. The second model describes the quelea population in the Ethiopian Rift Valley and the selective targeting of nesting colony groups for reducing damage to lowland sorghum in the Awash River Basin.

INTRODUCTION

The quelea is a bird pest of ripening cereals throughout grassland Africa. It is noted for its enormous aggregations. Roosts and nesting colonies can be of the order of 10^6 individuals, and clusters of these aggregations of the order of 10^7 birds (Jaeger et al. 1989*a*). Local damage can be severe (Jaeger and Bruggers 1989). Losses can be particularly hard on traditional farmers who subsist on sorghum and millet. Worldwide, this is the most important of all bird pest problems in terms of the magnitude of control efforts to reduce bird numbers.

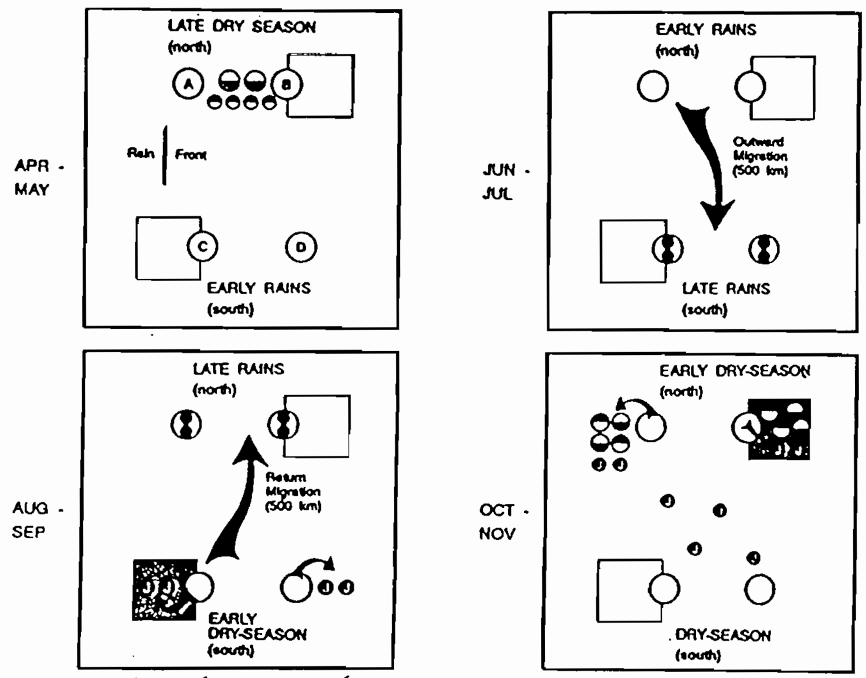
The principal means of control has been to destroy aggregations with avicides, usually organophosphates, sprayed by aircraft (Meinzingen et al. 1989). Widespread control operations during the 1950s and 1960s failed to have a long-term impact on the numbers of quelea or the damage they caused (Jones 1989). As a result, it was realized that the focus of control needed to be redirected to protecting the crop and not to eradicating the pest species.

Research efforts were intensified in the 1970s and 1980s during which time a variety of nonlethal control methods were evaluated (Jaeger and Bruggers 1989), including alternative agricultural practices (Elliott 1979). A fundamental problem with many of the methods used at the field level is that farmers will not employ them until after damage has begun. Small farms can be overwhelmed in the time it takes to organize the control program. In addition, where chemical repellents or bird scaring methods are used, the usual effect is to move quelea from protected to unprotected fields. Consequently, plant-protection organizations throughout Africa have not adopted these methods. Spraying avicides continues to be the preferred method of control. A goal of research has been to improve target selectivity. This refers to minimizing the number of aggregations sprayed, or their total area, by focusing on (1) only those quelea likely to do damage, (2) when and where they are the most concentrated, and (3) prior to the annual peak(s) in population numbers. To maximize target selectivity the spatial and temporal distribution of quelea populations must be understood in relation to the locations of vulnerable cereal. This will be illustrated with a general model that includes the annual distribution pattern of a quelea population, its migration, and nesting areas. This general model provides a framework upon which to better understand a second, more complex model, developed for the Ethiopian Rift Valley.

GENERAL POPULATION MODEL

Quelea population structure in eastern Africa is very complex, consisting of a number of separate populations, and possibly numerous subpopulations (Jaeger et al. 1989*b*). This complexity reflects the very patchy distribution, in both time and space, of resources necessary for nesting. The location of these resource patches, however, is predictable, and quelea aggregations tend to use traditional migratory routes and return to traditional nesting areas. Quelea are intra-African migrants. Their migration patterns are determined by the temporal pattern of rainfall together with the spatial distribution of habitat patches suitable for nesting. Other determinants include prominent landscape features used for navigation (e.g. rivers, coastline, the Rift Valley system) and barriers to movement (e.g. mountains, deserts, and forests). In eastern Africa, these factors result in a complex array of migration patterns. Quelea populations are, therefore, separated from one another by different migration patterns (Ward 1971), resulting in reproductive isolation, as evidenced by differences in male breeding plumage (Ward 1966).

The general model is illustrated in Fig. 1. It incorporates Ward's (1971) theory of quelea migration in relation to the annual movement of rain fronts back and forth across the equator. The four panels of Fig. 1 each represent the range of a hypothetical quelea population during successive seasons: the late dry-season, the early-rains, the late-rains, the early dry-season. During April-May quelea are concentrated in the north where it is late in the dry season. The annual rains have begun in the south; the rainfront is progressing northward. Roosts at this time, prior to migration, tend to be segregated by sex with the largest being predominantly male (Jaeger et al. 1979). By June-July the rainfront has advanced to the northern part of the population's range where the grass seeds, upon which the quelea feed, have germinated. The population has migrated south to where ripening grass seeds are available together with the other resources necessary for nesting. Nesting occurs in traditional areas, the distribution of which is very restricted in space and time. Adjacent to one of the nesting areas is a concentration of cultivated cereals which has not yet begun seeding and, therefore, in which no quelea damage is occurring. By August-September the rains have ended in the south, nesting has been completed, and the adults have returned to the north completing the migration. A second nesting then occurs. Nesting two or more times at different locations along the path of the rainfront is referred to as "itinerant breeding" (Ward 1971, Jaeger et al. 1986). Meanwhile most of the juveniles from the first nesting have remained in the south; and those from colonies adjacent to the now ripening cereal crop have begun to inflict damage. The crop in the north has not yet set seed. By October-November the second nesting in the north has been completed, the crop is now vulnerable, and both the adults and juveniles from nearby colonies have begun to damage this crop. The population at this time is at its annual peak in numbers and dispersion as indicated by the tendency for roosting aggregations to be segregated by sex and age.



Night roosts: adult ♂ - ◒, adult ♀ - ◓, juvenile ◉
Traditional nesting areas Ⓐ - Ⓓ : with nesting colonies - Ⓧ , without nesting colonies - ○
Traditional cropping area: with vulnerable crop - ▩ , without vulnerable crop - [_]

Fig. 1. A general model to explain the seasonal distribution of a quelea population in relation to vulnerable crops. See text for full explanation.

The simplest strategy for selective targeting is to treat only those nesting colonies in close proximity to concentrations of cultivated cereals. This strategy is widely practiced; and there is no indication that it tends to have a long-term impact on population numbers resulting in fewer nesting colonies in subsequent years. For the general model (Fig. 1) this strategy would have targeted colony group C in the south during June-July and B in the north during August-September. More complex situations occur, however, where crop damage regularly occurs in areas where there are no nearby nesting colonies.

In such situations it is necessary to determine the origin of aggregations causing damage. A second model will now be presented illustrating this problem. It describes the Ethiopian Rift Population and the steps used in determining a damage management strategy.

ETHIOPIAN RIFT POPULATION MODEL

Focus of protection

The primary objective of quelea management in Ethiopia is to protect lowland sorghum (*Sorghum bicolor*) in the Awash River Basin (ARB) and adjoining areas. In Ethiopia, sorghum is the predominant cereal grown in semi-arid conditions below 2000 m in elevation, where quelea are most abundant. The largest concentration of lowland sorghum is found along the base of the escarpment bordering the ARB (Fig. 2). This represents approximately one half the 500 000 ha of lowland sorghum produced in Ethiopia (Jaeger and Erickson 1980). Estimates of damage indicate that sorghum losses to quelea in the ARB system could reach 40 000 t/annum in the absence of control measures (Jaeger and Erickson 1980, Jaeger and Bruggers 1989).

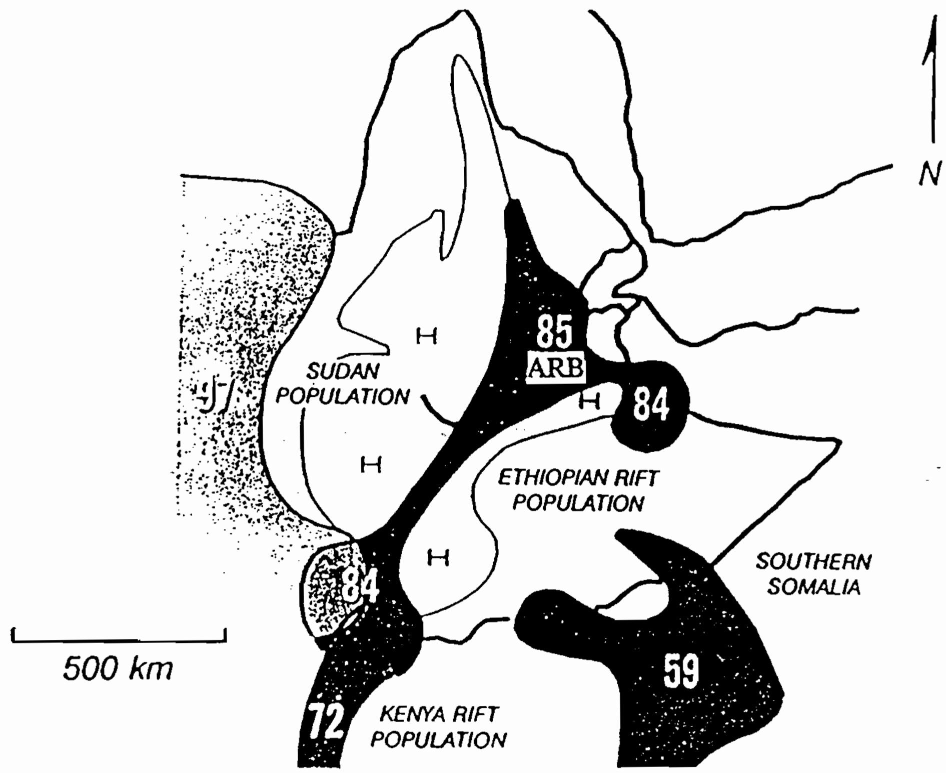


Fig. 2. Quelea populations in relation to the Awash River Basin (ARB) and the highlands (H) forming the Ethiopian Rift Valley. Numbers represent the percent of males with no black frontal bank over the bill. See text for full explanation.

Quelea populations

An initial step in determining the distribution of those quelea damaging sorghum in the ARB was to delineate the range of the quelea population(s) involved. Plumage differences have been used to distinguish populations that are polytypic for the composition of the black face mask types of adult males in breeding plumage (Ward 1971, Jaeger et al. 1989*b*). Mask type is polymorphic among individuals. An index developed by Ward (1966) to score mask types was used. On one extreme are males with no black frontal band over the bill, and on the other extreme are those with a broad band. Quelea were sampled for mask type in widely scattered sites in Ethiopia and adjoining countries (Jaeger et al. 1989*b*). Results indicated that a separate population occurs in the Ethiopian Rift Valley (ERV) and extends to the northeast into northern Somalia (Fig. 2). It is characterized by about 84% of males sampled having no black frontal band. The highlands which bound the rift isolate this population except in the southwest where overlap occurs with populations from Sudan (97% males with no frontal band) and the Kenyan Rift (72% males with no frontal band) (Jaeger et al. 1989*b*). It is the ERV population, therefore, which damages sorghum in the ARB.

The migration of the ERV population is fragmented in time and space. Here the axis of the rainfront is perpendicular to that of the rift. The result is that the population splits and the first nesting occurs in two separate areas during overlapping time periods: the southwest during May-June and in the northeast during June-July. During the return migration the population gradually reunites from August to October when a second nesting occurs in the ARB (Fig. 3). Therefore, nesting occurs in three general areas within the range of the ERV population (southwest, northeast, and ARB). Nesting colonies are usually grouped within traditionally used patches of nesting habitat (Jaeger et al. 1989*a*).

Selective targeting

The general model showed that for control to be most selective it should focus on nesting colony groups before they disperse. Which groups of nesting colonies should be targeted in the ERV? The breeding season for this population begins in the southwest, where nesting is more extensive than in the other two areas, due to the presence of colonies from neighboring populations (Fig. 2). Discrete variation among nesting colonies for the composition of male mask types suggests that populations remain at least partially segregated even though their ranges overlap at this time. As a consequence, the adults from each population complete their migrations in different directions as indicated in Fig. 3. Assuming that populations are indeed separate, a campaign to treat all nesting colonies in the southwest would not be selective in terms of protecting sorghum in the ARB.

In the northeast, nesting is in close proximity to concentrations of sorghum fields associated with the ARB (Fig. 3). Damage in this area can be severe. In 1976, for example, an estimated 51% of 35 000 ha representing approximately 18 000 t was destroyed by juvenile quelea near Jijiga, Ethiopia, before their roosts were located and treated (Jaeger and Erickson 1980). Nesting colonies in this area, therefore, seem important to target for annual control. This control has not been done due to the hostilities between Ethiopia and Somalia.

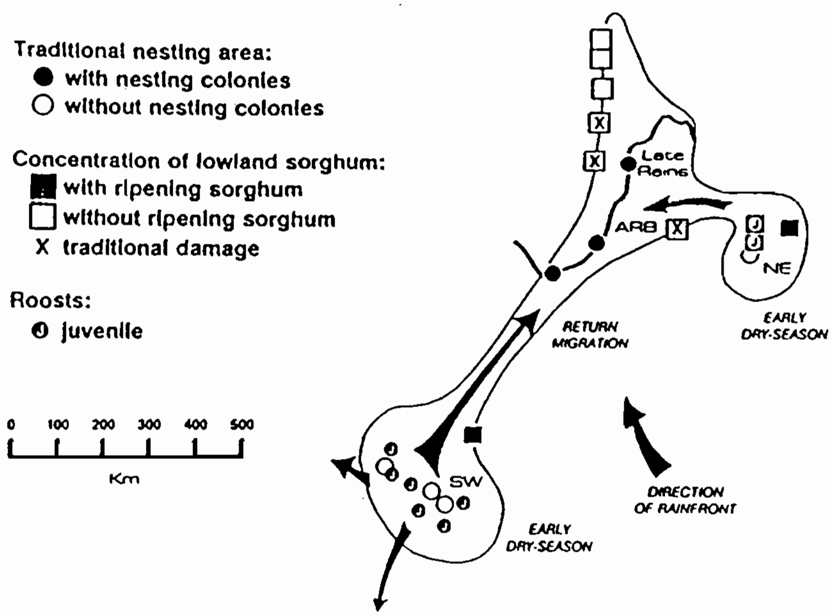


Fig. 3. Seasonal distribution of the Ethiopian Rift Valley quelea population in relation to lowland sorghum in the Awash River Basin.

In the ARB, following the second nesting, both adults and juveniles disperse from their nesting areas, and remain in the area posing a threat to ripening sorghum. The targeting strategy has been to ignore the nesting colonies in the southwest and to focus control on those in the ARB. Operational use of this strategy effectively reduced damage each year from 1978 to 1981 (Jaeger and Bruggers 1989), while not reducing the number of colonies in subsequent years. Evidently, not all nesting colonies were found, not all adults in the ARB bred a second time, not all quelea in treated colonies were killed, or some combination thereof. These survivors, together with juveniles from the first nesting, allowed the population to recover each year.

All nesting colonies that could be located in the ARB were treated each year (1978 through 1981) unlike the strategy described in the general model where only those nearby to sorghum concentrations were targeted. This was necessary because nesting colonies in the ARB were not adjacent to the major sorghum growing areas (Fig. 3) making it difficult to predict which of them were the most likely to disperse to the sorghum. However, there are indications these post-breeding movements of quelea could be predicted and that control operations within the ARB could be targeted selectively. Such predictability is suggested by long-term group cohesion, segregated movement among groups, and by the fact that both nesting and damage tend to occur in traditional areas each year (Jaeger et al. 1986) as illustrated in Fig. 3.

What appears to happen is that, after nesting is completed, the dispersing quelea follow drainages from nearby their colony sites to the sorghum-growing areas along the escarpment. The three traditional damage areas shown in Fig. 3 all drain into the vicinity of the northern most nesting area. This suggests that effective control might be achieved by targeting only this nesting area. This hypothesis could be tested by mass marking quelea in separate nesting areas with different colored fluorescent particles sprayed by aircraft, and later sampling for the marked birds in the damage areas (Jaeger et al. 1986).

CONCLUSIONS

1. The most effective strategy for managing quelea damage has been selective treatment of nesting colonies with aerially applied avicides before the onset of damage.

2. Opportunity for selective targeting varies among populations. For a management strategy to be most selective and cost-effective, it must be focused on a clearly defined cropping area, and the spatial and temporal distribution of the quelea population(s) damaging the crop must be understood.

3. An annual strategy of selective targeting requires that the spatial and temporal distribution of the quelea be predictable. Nesting areas, migration and dispersal patterns, and damage patterns are more predictable than earlier believed. However, drought, unseasonably favorable rains, and new land-use practices can reduce predictability.

4. There is no evidence that control campaigns have had a long-term impact on quelea numbers.

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